THE IMPORTANCE OF HEAT TOLERANCE IN CATTLE BREEDING

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Introduction

With the establishment of the National Milk Board a few years back the entire aspect of Animal Husbandry in Ceylon has undergone a change for the better, and overnight as it were the emphasis is on more milk production. The slogan may well seem to be 'More and Better Milk'. The question then arises as to whether we have the necessary potential among our cattle to produce this increasing demand. It is clear from work done in Ceylon and other Asiatic countries that the indigenous cattle which are mainly of the Zebu type are incapable of high production as compared with the exotic breeds like the Ayreshire, Freisian, and the Jersey. Of course the exceptions to this are the Indian milk breeds such as the Scindhi, and the Shahiwal.

In Ceylon the native cattle population is mainly composed of the Singhala breed, which is generally small in body size and low in production. The average milk yield per lactation is about 60 gallons. This small body size and very low production may to a great extent be attributed to a very low plane of nutrition, and an equally low standard of management.

Methods of Improvement

Although it must be conceded that any form of livestock improvement on a long term basis should be built up around the indigenous stock using such methods as selection and up-grading, yet such methods will not meet the *immediate* need for an increase in milk production. It therefore becomes imperative that if an appreciable increase in milk is to be attained within a few years, then other methods have to be resorted to. One of the most promising and logical step forward would be to cross-breed the low yielding indigenous stock to high yielding exotic breeds.

Before passing judgement on such a scheme it would be worthwhile to review work done in other countries on similar lines. A study of cattle improvement projects will show that attempts have been made at various times to import high yielding dairy stock, and transplant them in environments that differ very markedly to the habitats where they have performed well. The results of these ventures have either been disappointing or in some cases ended disastrously. This has been true in the tropics that are characterized by high temperatures, heavy rainfall during certain seasons, very poor quality roughage, and innumerable insect pests and diseases.

Where attempts have been made to cross the indigenous stock to the exotic breeds, and subsequently back-cross the progeny to exotic similar disappointments have been experienced. In these cases after the first cross-bred generation which exhibit the usual hybrid vigour milk yields tend to fall to the same level as that of the native stock. For instance in the West Indies repeated back-crossing to the Freisians, increased the culling rate to 60 per cent, and in the Philippines when repeated back-crossing was done to Ayreshire mortality among young stock rose to over 50 per cent.

However work now been done by the Ceylon Department of Agriculture (1) suggests that instead of back-crossing to the exotic parent, the second generation should be derived by mating the cross-breds. It is suggested by this method that the economic factors such as milk production will not vary significantly from the F_1 to the F_2, so long as the difference between parents is small, the heritability is low, and the number of genes involved are high. The results obtained to date are very encouraging indeed.

The Effect of Climate

The results of repeated back-crossing to the exotic parent is for the resultant progeny to become more and more like the exotic parent with each succeeding generation, and succumb to the stresses of the rigorous climate.

The animal kingdom can be divided into two classes based on their body temperatures. One the cold blooded animals that can adjust themselves to wide variations in temperature, and to changing environments, whereas the second group the warm blooded animals, can tolerate only relatively small variations in body temperature, and their main task is to keep heat produced in the body at a balance with the heat lost from the body. Therefore if animals are to survive and do well in the tropics they must have an efficient heat regulating mechanism, or otherwise the ability of the animal to keep heat produced balanced by heat loss would be upset.

The climate in the tropics affects production both directly and indirectly. Indirectly it affects by its effect on pastures and crops. Secondly, given an adequate plane of nutrition and an ideal standard of management, climate has been shown to play a direct role in the well being and production ability of the animals. It is a recognized fact that although cattle native to the tropics are inferior in production to the exotic breeds yet the former have a higher level of resistance to climatic stress than the latter. Such animals can eliminate large amounts of body heat without appreciable loss in production i.e. they are heat tolerant.

Heat Tolerance

Therefore the question that now arises is as to whether it is possible to retain this high degree of heat tolerance while at the same time increasing the level of production. One possibility that has been drawing the attention of field workers is to see whether they could select animals with a high degree of tolerance to heat stress.

Many empirical tests of adaptability to heat stress have been worked out. One such test is known as the 'Iberia Heat Tolerance Test' which assesses the ability of cattle to withstand heat by measuring the increase in rectal temperature which occurs in the animal after a day in the sun at 90°F. If the animal succeeds in maintaining the body temperature at its normal value of 101°F, then on the basis of this test its adaptability to heat is 100 (vide Fig. 3, page 9). The formula used to get this figure is $100 - 10(BT - 101 \cdot 0)$ BT = Body Temperature.

Using this test it was shown that the adaptabilities of Brahaman, Santa Gertrudis, Jersey, Hereford and Angus cattle were: 89, 82, 79, 73 and 59 respectively. The European-cattle thus show a large range of adaptability, differing degrees of heat tolerance are therefore not solely confined to differences between tropical and European type cattle.

Other field workers have found that certain characteristics of individual aimals even within the breed, may significantly affect heat tolerance. Bonsma (2) in South Africa has shown that the ideal type of coat for high adaptability to stress is smooth, glossy and short hairs which are white in colour, and should not felt when a handful is rubbed together. Yeats (3) in Australia proved that a long woolly coat is associated with poor heat tolerance and that the length of coat hair was controlled by light. Having demonstrated that the normal seasonal change of coat of European cattle is controlled by a changing photoperiod, it at once becomes apparent that the tropical light environment in which seasonal change in length of day may be negligible holds special problems in adaptation.

Therefore the picture that gradually emerged from these studies was that not only were there significant differences in heat tolerance between European and Tropical Stock, but of greater significance was the fact that there were similar differences *within* pure European and Tropical Stock. This finding made it clear that, in order to establish a sound basis for selection, much more would have to be known about the physiological basis of heat tolerance than could be learnt from field experiments. The latter involves too many variable factors.

Controlled Study of Climatic Factors

A climate is made up of the variables of temperature, humidity, air-movement, radiation, rainfall and barometric pressure. While all these factors affect animal physiology, two of these which affect them most can be very readily stimulated in the laboratory. These two are temperature and humidity. While air movement can also be stimulated to some extent. To study the physiological reactions of animals to these factors animals have been put into rooms in which any desired temperature and humidity can be produced and held constantly and accurately to heat stress. In these rooms their body, blood and rectal temperatures and breathing and pulse rates are measured.

A calf subjected to a temperature of 80°F at a low or high humidity shows no discomfort, but above this temperature however its body temperature begins to rise, its pulse rate increases, and its breathing rate increases rapidly until under dry conditions at 104°F it reaches 5-6 times its normal value. This panting, which is really the blowing of large amounts of air over the wet breathing passages is one of the principal means by which cattle lose heat. Often under severe conditions this breathing rate is above 250 a minute, and such a high rate involves much muscular effort and energy is thus expended in the animals' effort to keep cool, which might otherwise go into productive purposes.

It was found that by exposing a number of calves to various heat stresses and measuring their reactions, their general heat tolerance could be compared. The individual variation in tolerance between calves—all of Ayreshire breed, of the same age and approximately the same weight and all identically fed and managed are striking. For instance eight calves each exposed to a temperature of 104°F for three hours showed body temperatures ranging from 102°F-106°F after 100 minutes, while their breathing rates ranged from 115-175 per minute after the same time under same stress. Therefore it could be surmised that some were very tolerant, while others were very intolerant. This work further suggested that calves could be acclimatised to high temperatures, by repeated exposures to it. If the physiological basis for this acclimatisation could be found it would greatly aid in devising a test of selection for high heat tolerance.

Other workers notably Worstal and Brody (4) have subjected cattle to a variety of conditions (Temperature, Humidity, Air-movement and Radiation) from temperatures between 0°F-105°F. Comparative reactions at critical levels are given below.

Breed Reactions to Temperature (Degrees Fahrenheit)

Reaction	*Jersey*	*Holstien*	*Brown Swiss*	*Brahaman Zebu*
Food consumption decreases above ..	75	70	80	95
Milk production decreases above ..	85	85	85	95
Body weight decreases above ..	85	80	80	—
Body temperature rises above ..	75	70	80	95
Breathing rate increases above ..	60	60	60	75
Pulse rate increases above ..	100	90	95	100

*The critical temperature is the air temperature after which marked changes occurred in the reactions.

In Missouri workers have also attempted to define the ' Comfort Zone ' for European cattle ; i.e. the zone of temperature ideal for optimum production and within which the animal neither shivers nor eats more to keep warm, nor pants to keep cool. Their work indicates that this zone lies between zero and 60°F, depending on the productive level of the animal. The higher this level the more tolerant to cold it becomes, as high production means a higher food consumption and this in turn means a production of extra heat.

In general with air temperature below 80°F humidity has no effect on cattle, since they can get rid of all excess heat without using evaporation to any great extent. Above this temperature the effect of increasing humidity of the air is to make the evaporative loss more difficult, and has the same reaction from the animal as a rise in temperature. For example at the Hannah Institute calves subjected to a temperature of 86°F at a humidity of 77 per cent had the same effect as those exposed to an air temperature of 93°F and humidity of 50 per cent.

Much work has been done to find out the relative function of the sweat glands, and what role they play in heat tolerance. While it is true that Zebu cattle have significantly more sweat glands than the European breeds, yet Worstal and Brody (1955) concluded that cattle did not sweat. It is likely that the physical cooling of the pappilary layer by the absorption of heat for vapourization of sweat is a vitally important factor in maintaining a normal body temperature. This pappilary layer contains the follicles and glands. It was found for instance by Dowling (5) that there was no difference between the total skin thickness between a Shorthorn and a Zebu under good nutrition, but there was a very surprising difference in the relative thickness of the skin layers (vide Fig. 1). In the thin pappilary layer of Zebu the glands are more numerous and better developed. A sebaceous gland and an acropine gland are associated with each hair follicle, and the voluminous acropine glands are closer to the surface. Correspondingly the reticular layer is thicker, firmer and denser in the Zebu than in the Shorthorn. The subcutaneous muscle layer is better developed in the Zebu and therefore has a better control of skin movement.

In the tropics where atmospheric temperatures tend to be high, cattle of the exotic breeds tend more often than not to seek shade during the hot parts of the day and this was proved by Payne, Lang and Raivoka (6) in Fiji, while Goonesekera (7) working with indigenous cattle (Zebu) in Ceylon showed that these animals did the bulk of their grazing during the hottest part of the day (vide Plates 1 and 2) and preliminary work done subsequently at the C.R.I. suggests that increases in atmospheric temperature had no effect on rectal temperature of indigenous cattle, and they did not show any signs of heat stress, while this was quite the opposite for

FIGURE. 1

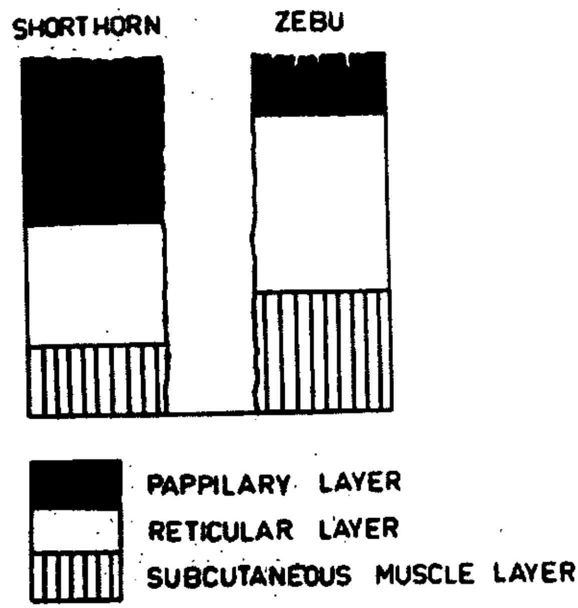
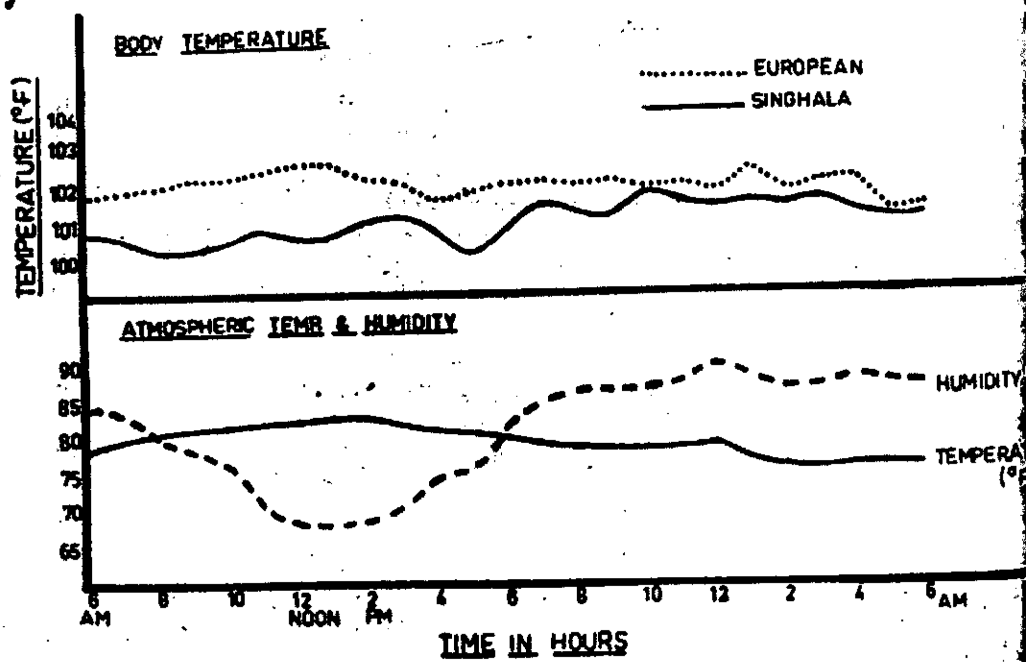


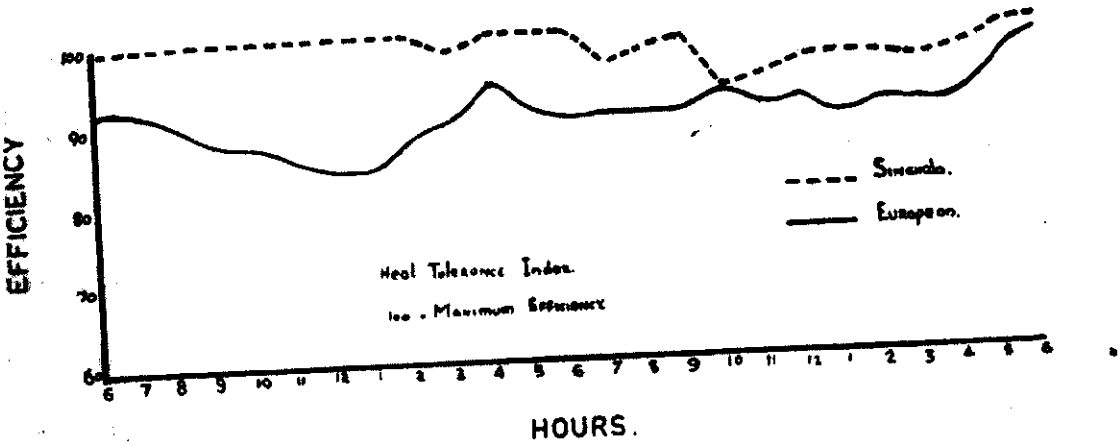
Figure. 1 Shows the difference in thickness of Shorthorn and Zebu skin layers under adequate nutrition, (After Dowling)

FIGURE. 2



European cattle (vide Figs. 2 and 3). However, it also showed that with increasing humidity rectal temperatures of indigenous cattle had a tendency to rise, but in the case of European stock a rise in rectal temperature was noted with a rise in atmospheric humidity.

FIGURE·3



Heat Tolerance and Dwarfism

Small size or dwarfing appears to be a special feature of local indigenous cattle. This dwarfing does not seem to be peculiar to Ceylon only, but also to parts in India such as Bengal and the west coast of Madras, in Nigeria, Malaya and to certain West African territories. The observation indicates that dwarfing of cattle is a normal accompaniment of the hot humid climate which appears typical of the wet tropics.

As stated earlier tropical climates impose a severe strain on the heat regulating mechanism of the animal. Studies carried out at various times have shown that Zebu cattle are able to withstand high temperatures due to the following reasons :—

(1) They have short, dense, glossy hair which reflect light.
(2) Their skin is thick and impenetrable.
(3) Their skin area is large and this is indicated by the looseness of the skin as typified in the large dewlap and pendulous sheath. The large skin area increases the potential capacity for cooling.
(4) Zebu cattle appear to have an efficient sweating mechanism, which further enhances the cooling capacity of the skin. While the sweating mechanism is of great value in hot dry areas, its effectiveness is considerably reduced in hot wet areas such as Ceylon where the humid atmosphere hinders evaporation. On this consideration it may be suggested that under such climatic conditions dwarfing may be a necessary pre-requisite to producing a suitable heat regulating mechanism.

With a small sized animal heat transfer from the interior of the body to the surface is easily achieved. Moreover in such animals the ratio of skin area to body weight increases which results

GRAZING OBSERVATION COW NO. 1

JULY 1952——JUNE 1953

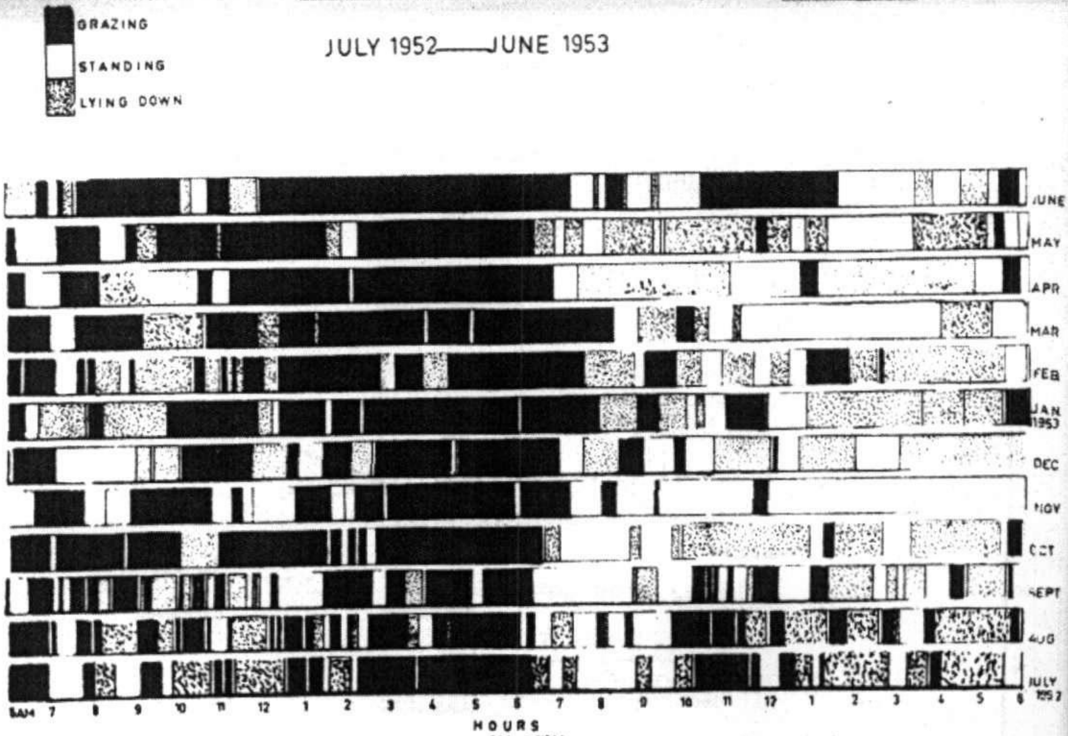


PLATE 1

GRAZING OBSERVATION COW NO. 3

JULY 1952——JUNE 1953

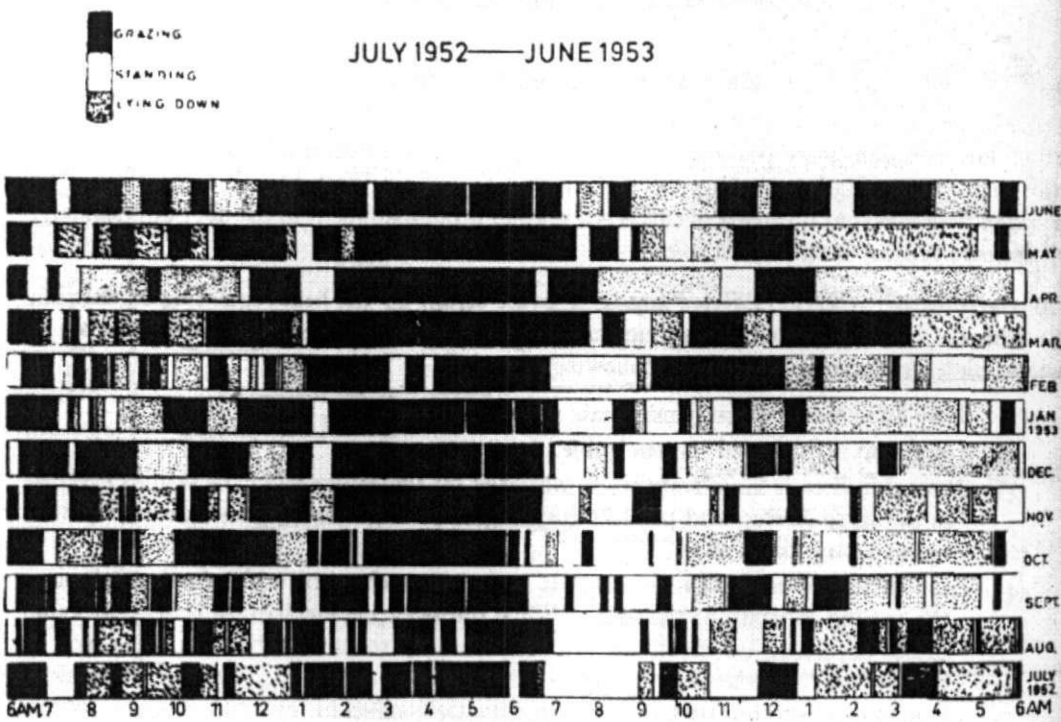


PLATE 2

Shows typical grazing patterns of Indigenous (Sinhala) stock over a year long basis.

in an increased cooling capacity. Experiments in U.S.A. have shown that an animal of the half the normal weight will show a 20% increase in skin area per 1 pound body weight and will possess a proportionally increased cooling capacity.

In small sized animals the metabolic rate is low, and therefore the output of body heat is low, and naturally the food intake is also low. All these factors reduce the strain on the heat regulating mechanism. It will also result in diminished growth rates, decreased body size and low levels of production, which are all typical of the indigenous cattle in Ceylon.

Therefore it appears that dwarfing is a natural adaptation to unalterable conditions of climate, to a low plane of nutrition and also to a poor standard of management.

Conclusion

It is evident in this discussion that the failure of exotic breeds and their offspring obtained by back-crossing is due to their inability to withstand the heat stresses imposed on them by a tropical climate. It should therefore be noted that while cross breeding will increase the level of production, every effort should be made to select animals with a high degree of heat tolerance. This selection should not be restricted only to cross breds but to both purebred European and Zebu stock.

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